DETECTABILITY OF DARK MATTER AND NEUTRINOS IN A GAS TPC

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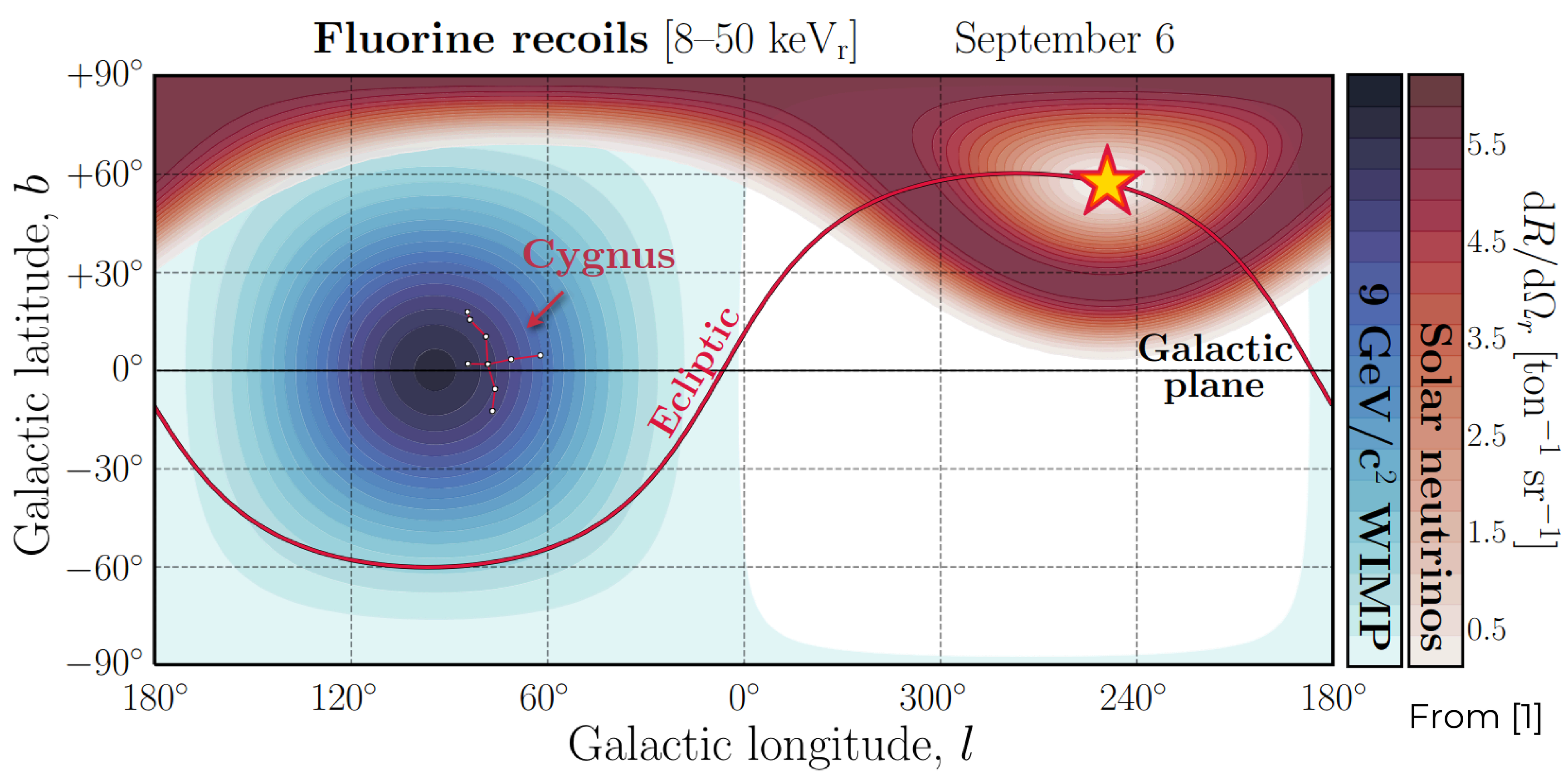
MOTIVATION

Neutrinos produce both electron and nuclear recoils, while WIMPS *O*(GeV-TeV) are expected to primarily produce the latter

The spectra of nuclear recoil energies caused by these particles look **very similar**, making neutrinos a **problematic background** for the next generation of dark matter searches

It is their direction of origin which makes them **distinguishable**



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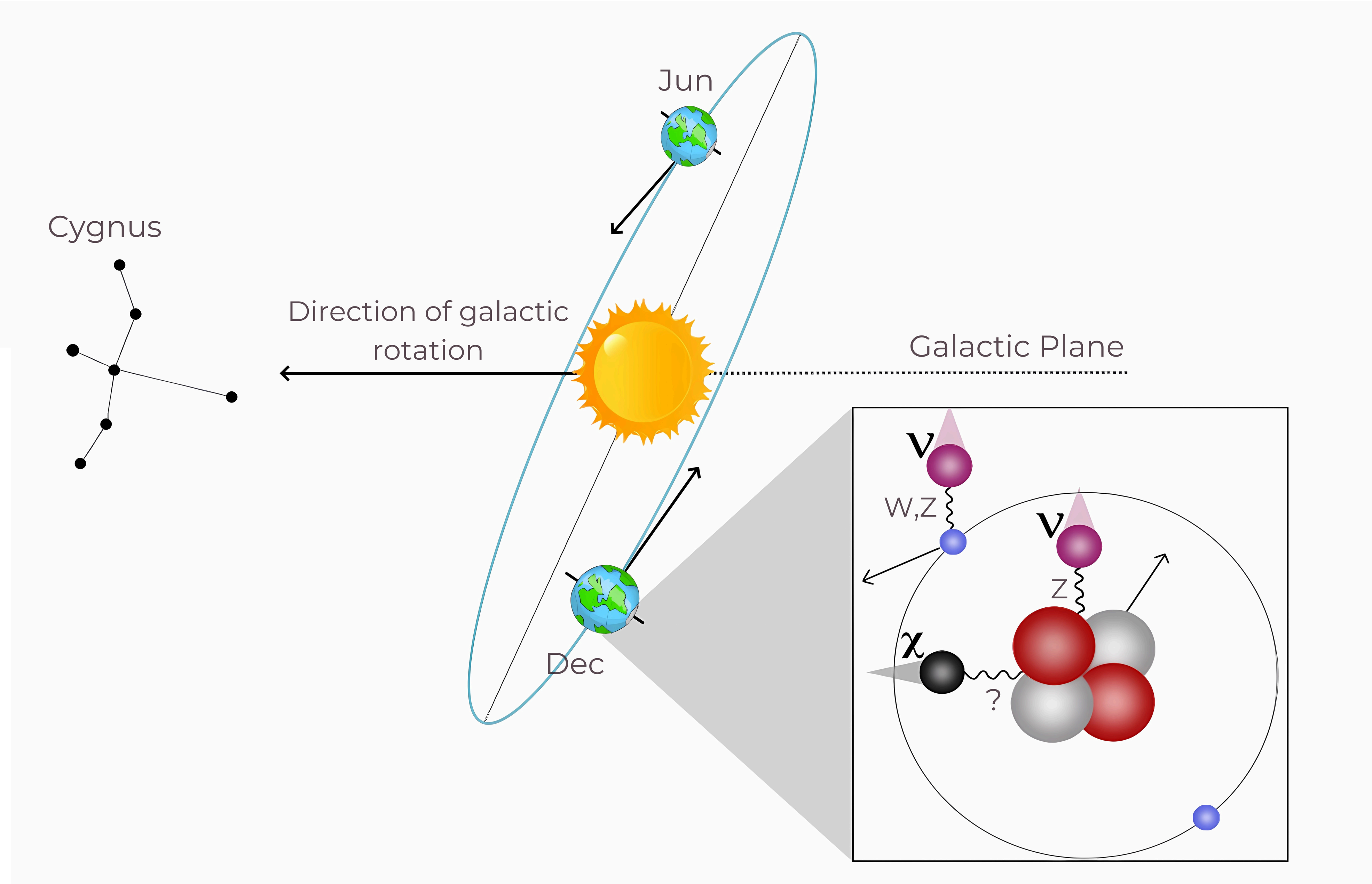
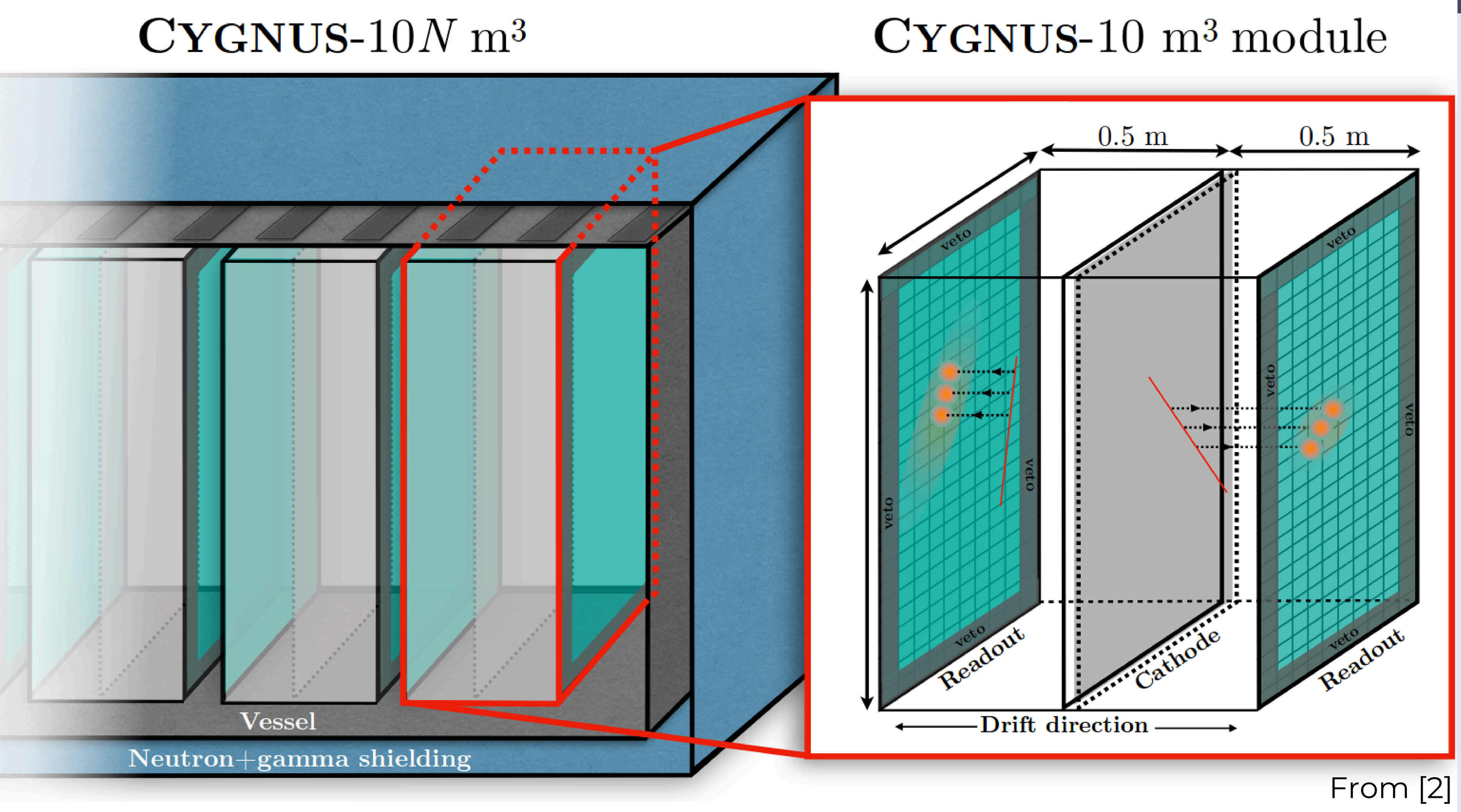


CYGNUS EXPERIMENT

The CYGNUS project is developing technology to detect the directions of the recoils

The CYGNUS experiment would include:

- N gas time projection chamber **(TPC) modules**, each made up of two segmented readout planes separated by a cathode
- An electric field to transport the ionisation track formed by the recoils to the readout plane



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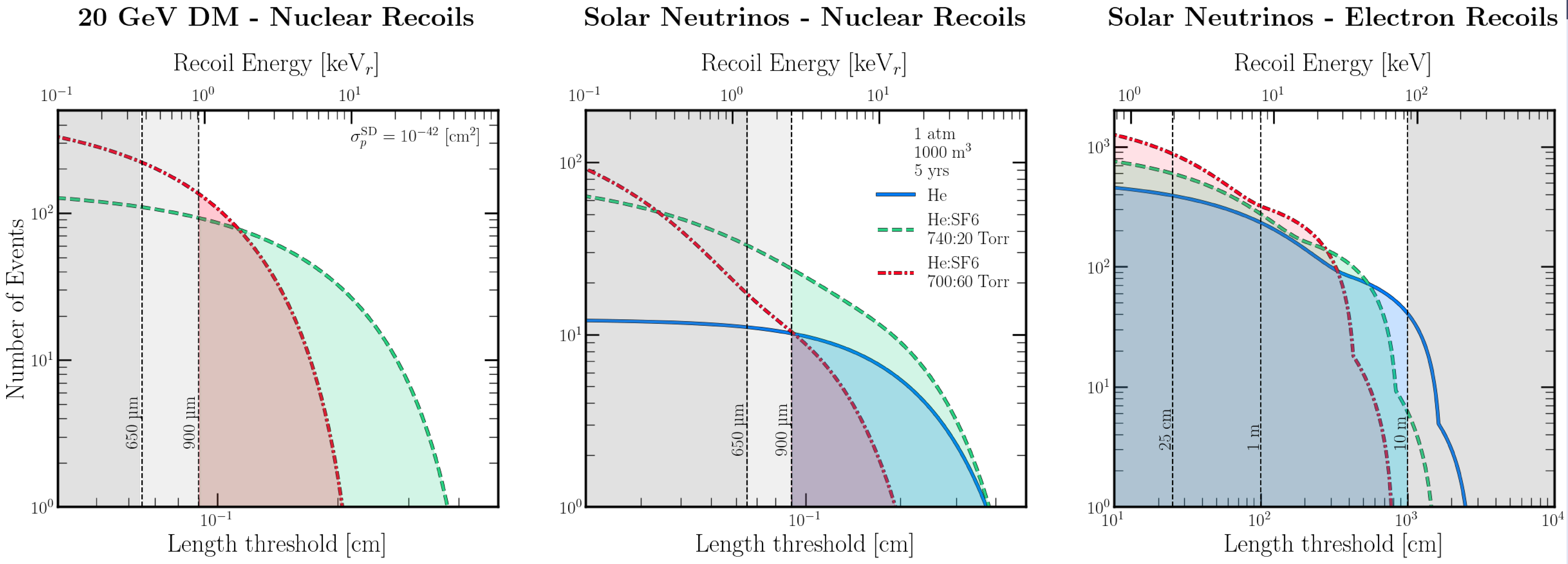
AIM

Detecting the recoil directions means being able to **discriminate between different recoil sources,** and distinguish these from the background

- While nuclear recoils are short and have large ionisation density, electron recoils are long
- To maximise detection, it is desirable for the target mass to be as large as possible, without making the experiment too big or the gas too dense

The aim is to **optimise the experiment's operating parameters** to obtain as much physics as possible



RESULTS

The plot shows the expected number of recoil events whose length is above a certain threshold versus the threshold itself for different gas mixtures

We impose two limits:

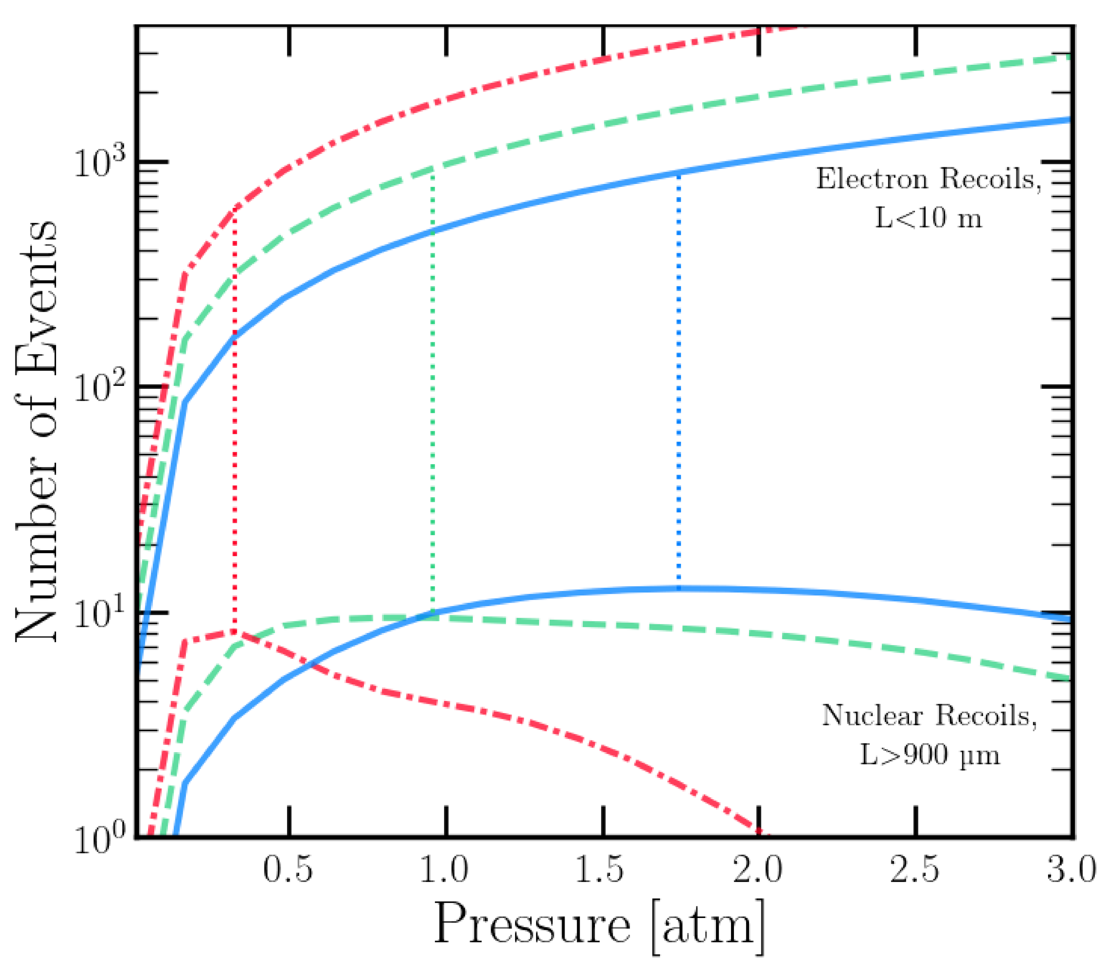
- A **minimum** track length, equal to the typical **diffusion** for gases at pressures of 1 atm
- A **maximum** track length equal to the **size of the detector** itself

The events outside of this range are greyed out

CONCLUSIONS

The **optimal conditions** for the electron recoil tracks to be contained in the detector (1mx10m) and those for nuclear recoil tracks to be longer than the diffusion scale (900 μm) **are conflicting**

This can be seen on the right, where the colours correspond to the same mixtures as above. The vertical lines highlight the maxima for the nuclear recoil curves: **an experiment that has optimal sensitivity to low-energy nuclear recoils does not have optimal sensitivity to electron recoils**



FUTURE PLANS

This analysis is independent of the recoil directions. A further optimisation would include that information

This will make it possible to predict the **optimal orientation of the readout plane** given a certain position of the detector

In fact, a solution to the optimisation issue we encountered would be to **maximise the length** over which the electrons travel by **aligning the readout planes of the TPC East-West**

[1] Vahsen, S.E., O'Hare, C.A., Loomba, D. "Directional recoil detection." (2021)
[2] Vahsen, S. E., et al. "CYGNUS: Feasibility of a nuclear recoil observatory with directional sensitivity to dark matter and neutrinos." (2020)